From Beer to Crack: Developmental Patterns of Drug Involvement

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ABSTRACT

Objectives. Prior research has identified developmental stages in drug use in adolescence, from substances that are legal for adults to illicit drugs. The position of crack in patterns of drug involvement remains to be established.

Methods. The analyses are based on a sample (n = 1108) representative of 12th graders attending New York State public and private schools. From reported ages of first use of five classes of drugs (alcoholic beverages, cigarettes, marijuana, cocaine but not crack, crack), alternate models of progression were tested for their goodness of fit through log-linear models.

Results. The sequence involves at the earliest stage the use of at least one licit drug, alcohol or cigarettes. Subsequent stages involve marijuana and cocaine; crack is the last drug in the sequence. The results confirm the more important role of alcohol among males and cigarettes among females in the progression into various drug classes. Age of first drug use at a lower stage is a strong predictor of further progression.

Conclusions. The developmental pattern of drug involvement identified in the early 1970s still characterizes adolescent pathways of drug involvement in the late 1980s. (*Am J Public Health.* 1993;83:851–855)

Introduction

Prior research has identified clear developmental stages in involvement with drugs. The use of substances that are legal for adults (i.e., alcohol and cigarettes) tends to precede and to increase the risk of initiating the use of illicit drugs. Adolescents are very unlikely to experiment with marijuana if they have not experimented previously with an alcoholic beverage or with cigarettes; very few try illicit drugs other than marijuana without prior use of marijuana.[1–6]

Crack, which appeared suddenly in urban centers in the 1980s, has been thought to represent a completely new pathway of entry into drug use, disrupting the normal social processes attending drug initiation and progression to various other forms of drug use.[7,8] Although it was commonly believed that young people begin using drugs directly with crack, this hypothesis remains to be confirmed. Little systematic epidemiological data are available on the use of crack among untreated samples of adolescents and young adults.[8–10] This paper focuses on patterns of drug involvement in adolescence and on the position of crack in these patterns.

Subjects and Methods

A statewide epidemiological survey of the use of alcoholic beverages, cigarettes, marijuana, cocaine, crack, and other illicit drugs was carried out among 7611 students in grades 7 through 12 in New York State in spring 1988. The two-stage random sample represents junior and senior high school students attending New York State public and private schools. A stratified sample of 54 schools and two homerooms from each grade per school was selected. The four stratification criteria for school selection were geographical area, proportion of White enrollment, public versus private status, and enrollment size. The sample was weighted to reflect the variable probabilities of selection of schools and homerooms and the grade-specific absentee rate in each school.

On anonymous, self-administered, structured questionnaires given out in classrooms (84% completion), the students were asked about beer, wine, hard liquor, cigarettes, marijuana, stimulants, inhalants, cocaine (and crack), psychedelics, sedatives, tranquilizers, and heroin. Age of first use was asked with regard to five classes of drugs: three alcoholic beverages, cigarettes, marijuana, cocaine in any form (excluding crack), and crack. Because of strong age-related patterns of drug use,[11] the analyses were restricted to seniors (n = 1108), who have had more opportunities than any other grade to experiment with various classes of drugs. Among the total sample, 95.7% of students reported using at least one of these drugs. In the absence of longitudinal data on cohorts over time, analyses of self-reported ages of onset into these drugs were relied on to infer potential sequential patterns.

To identify major pathways of progression and the efficiency of different cumulative models of initiation in fitting the data, modified log-linear Guttman scale models for the analysis of sequencing of events were used. These statistical proce-

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TABLE 1—Pairwise Comparison of the Order of Age of Initiation for Five Classes of Drugs, among 12th Graders Who Used Both Classes of Drugs

Drug A	Drug B	Proportion of Specified Ordering: Drug A before B, %	Same Age, %	Drug B before A, %	Total n
Alcohol	Cigarettes	47.2	24.9	27.9	789
Alcohol	Marijuana	80.3	15.0	4.7	578
Alcohol	Crack	96.1	0.0	3.9	118
Cigarettes	Marijuana	70.8	20.7	8.5	534
Cigarettes	Any cocaine	89.7	9.1	1.1	143
Cigarettes	Crack	89.7	5.9	4.4	32
Marijuana	Any cocaine	88.0	11.2	0.8	150
Marijuana	Crack	82.6	7.0	10.4	36
Any cocaine	Crack	44.2	42.5	13.3	35

dures can test the fit of entire sequences, as well as of alternate trajectories involving deviations from a major developmental sequence and not only a two-event transition probability table.

Five drug classes were distinguished: alcoholic beverages, cigarettes, marijuana, cocaine (excluding crack), and crack. Analyses of progression were based on the age of onset for each drug class. (Students who had used no class of drugs [5% of men, 4% of women] were included. Students with three or more ties were excluded; those with two ties were distributed proportionally to the order observed for the relevant drug classes.) Major pathways of progression were identified from the ordering of initiation among the five drug classes, and specific cumulative progression models or scale types were hypothesized and tested for fit to the data.

The proportion of persons classified in the scale type beyond that expected from the prevalences of use was estimated. For a given model, the observed proportion of individuals who could be classified in the scale type was calculated, although not all individuals were required to reach the highest stage in the progression. In testing the fit of a model of progression, it is important to ascertain also the expected proportion of individuals who fall in the scale type that is not owing to chance. For a given specification of scale and nonscale types, and assuming that the nonscale type can occur only by chance, the maximum likelihood estimates of six parameters was obtained. One parameter, λ, is a constant fixing the total frequency of persons whose pattern of progression, which may or may not end in the scale type, occurs by chance—that is, the random type group; the other five parameters, λ^{A}_{i}, λ^{C}_{j}, λ^{M}_{k}, λ^{O}_{l}, and λ^{P}_{m}, fix the marginal probabilities of initiation for each class of drugs among persons in the random type group. The expected proportion of persons in the scale type not owing to chance is given by [f-F (chance)]/f, where f is the observed frequency and F (chance) is the frequency expected by chance. (The proportions who follow the hypothesized scale types and patterns include two latent groups, one in which the patterns are owing to chance and one in which they are not. The proportions of scale types expected by chance are estimated from the parameters for the nonscale types; these proportions are subtracted from the observed proportions in the scale types to provide the proportions in the scale types expected not by chance.)

To compare the fit of alternate models, the Bayesian Information Criteria (BIC) statistic[12,13] was used:

$$\text{BIC} \equiv G^2 - (df)\text{LOG}(N),$$

where G^2 is the likelihood ratio statistics for the goodness-of-fit test, *df* are the degrees of freedom, and *N* is the total frequency of observations. The statistics can be used for comparing nonnested and nested models and is especially appropriate for large samples. When two models are being compared, the model with a smaller (i.e., larger negative) BIC value is superior. (A model that adds one more parameter is superior if the G^2 reduction is larger than ln(N), where N is the sample size.)

To adjust for sampling variability and clustering, sampling variabilities and the design effect (1.2) were taken into account.

Results

Age of First Use

Cigarettes and alcoholic beverages, especially beer and wine, were initiated at an earlier age than illicit drugs. On average, marijuana was initiated at age 14.6 (SD = 2.0), 2.5 years later than cigarettes ($\bar{\chi}$ age = 12.9, SD = 2.4) or alcoholic beverages ($\bar{\chi}$ age = 12.5, SD = 2.6). Cocaine ($\bar{\chi}$ age = 15.9, SD = 1.6) and crack ($\bar{\chi}$ age = 15.8, SD = 2.0) were initiated slightly more than a year later than marijuana.

Pairwise Comparisons of Drug Use Initiation

Comparison of the ages of first use of drugs among adolescents who had used any pair of drugs provides important information regarding the potential sequence in which different drugs were initiated. The patterns are striking (Table 1). For the great majority of students, alcoholic beverages and cigarettes were initiated prior to the use of any illicit drugs. Of the illicit drugs, marijuana was initiated first; only 1% of the students used cocaine before marijuana. An order is least well established between cocaine and crack. More than 40% initiated both drugs at the same age; of those who did not, more than three times as many tried crack after having experimented first with other forms of cocaine as the reverse. The overwhelming majority of crack users had used marijuana before.

Tests of Specific Sequential Models among Male and Female Adolescents

To identify stages of progression beyond the pairwise comparison of two events, the analytical strategy outlined above was implemented. The following basic sequence of progression was hypothesized: alcoholic beverages, cigarettes, marijuana, cocaine, and crack. The baseline model assumed independence and no ordering. Alternative specifications of sequences of drug use progression were tested.

The four models that were initially tested specified different roles for licit drugs as a stage preceding the use of illicit drugs: alcohol *or* cigarettes were assumed to precede marijuana in model 1; only alcohol preceded marijuana in model 2; only cigarettes in model 3; and both alcohol *and* cigarettes in model 4. In each model, marijuana was assumed to precede cocaine and crack. No order was assumed

between cocaine and crack. The results indicate that all models fit the data quite well (Table 2). (Because the data are sparse, the χ^2 test of the absolute fit of the models with the data may not be very accurate. But the comparisons of nested models by the likelihood ratio tests that involve only several parameters are still adequate.[14] Similarly, the comparison of relative goodness of fit by the BIC statistics are adequate here.) The best-fitting models differ slightly between the sexes. Among females, the best fitting model is model 4; among males, models 2 and 4 appear to fit the data equally well.

We next tried to refine the best-fitting sex-specific models by testing three additional hypotheses in nested models. Hypothesis A tested a weaker role for cigarettes in the sequence than is required by model 4. It specified only that cigarettes were required—not necessarily prior to marijuana but further on in the sequence, prior to cocaine and crack. Hypothesis A could logically be applied only to model 2. The other two hypotheses, by contrast, constrained the models further by requiring specific orders between selected drugs. Hypothesis B specified that alcohol precedes cigarettes and hypothesis C specified that cocaine precedes crack.

These three hypotheses were tested in a sequential order. At each step, the best-fitting model identified in the prior step was taken as the starting basic model for the next modification. For males, the addition of hypothesis A, which posits that cigarettes precede cocaine and crack (model 2 + A), improves the fit of model 2 according to the BIC statistic. Because models 2 and 4 provided an equal fit, modification 2 + A clearly indicates the superiority of that model, not only over model 2 but also over model 4. For females, model 2 + A is worse in fit than model 4. The loosening of the ordering constraint involving cigarettes provides a poorer fit than a more rigorous ordering in which cigarettes play a role early in the sequence of drug involvement, prior to marijuana initiation.

For both sexes, the addition of hypothesis B, which posits an ordering between alcohol and cigarettes, worsens the fit of the models significantly (model 2 + A + B vs model 2 + A for males; model 4 + B vs model 4 for females) (see Table 2). No clear ordering exists between alcohol and cigarettes. The incorporation of hypothesis C, which posits that cocaine use precedes crack, improves the fit of the models for both sexes: compare model 2 + A + C vs model 2 + A for males; model 4 + C vs model 4 for females. The joint inclusion of modifications A and C in model 2 provides the best-fitting model for males. For males, cigarettes can be considered a more important precursor to the use of illicit drugs other than marijuana than it is to the use of marijuana. The improvement in fit provided by hypothesis C suggests that the distinction between cocaine and crack is informative. (To test this conclusion further, we also tested modifications of the best-fitting models in each sex, Models 2 + A, the best model for males, and Model 4, the best model for females, by omitting one of these two drugs [either cocaine or crack] as a requirement for the scale-type progression. Models that replace cocaine and crack with either cocaine exclusively or crack exclusively have a poorer fit [see the last four rows in Table 2].)

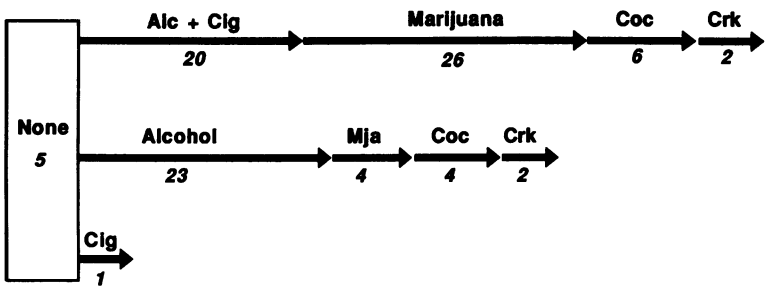
Thus, the best-fitting model for males is model 2 + A + C: (1) alcohol precedes marijuana; (2) marijuana and cigarettes precede cocaine and crack; and (3) cocaine precedes crack. The model classifies most parsimoniously 93.4% of the males, 91.4% not by chance. The best-fitting model for females is model 4 + C: (1) alcohol *and* cigarettes precede marijuana; (2) marijuana precedes cocaine and crack; and (3) cocaine precedes crack. The model classifies most parsimoniously 94.2% of the females, 91.8% not by chance. (Among males, a majority (28.6%) of the nonscale types involve the use of crack compared with 1.8% among females. Among the male nonscale types, 65% reflect the use of crack prior to cocaine. Of all the male crack users, 53.7% had used all drugs in the prescribed sequence.)

Graphic displays of the stages of progression among males and females and the proportions who reached each sequential stage are presented in Figures 1 and 2. For both sexes, the progression to crack occurs when experience with both alcohol and cigarettes have taken place prior to experience with marijuana. Males who initiate cigarettes after marijuana may subsequently experiment with cocaine but do not progress to crack, at least not until the adolescent years of 17 to 18 covered by this analysis. A small proportion of crack users—7.9% among males, 4.9% among females—do not fit the pattern of experimentation with a legal drug and marijuana

TABLE 2—Tests of Alternate Models Describing Pathways of Involvement in Five Classes of Drugs, for Males and Females (12th Graders)

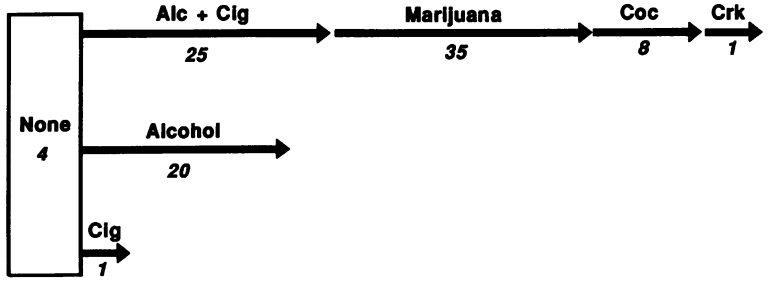
	Males (n = 540)			Females (n = 568)		
	G^2	*df*	BIC[a]	G^2	*df*	BIC[a]
Independence model	965.2	320	−1047.9	1003.4	320	−1026.4
Basic stage models[b]						
Model 1	58.7	273	−1658.7	15.2	273	−1716.4
Model 2	69.8	289	−1748.3	23.0	289	−1810.1
Model 3	163.1	289	−1655.0	48.3	289	−1784.8
Model 4	170.5	305	−1748.3	52.5	305	−1882.1
Modifications of models 2 and 4[c]						
Model 2 + A	89.4	299	−1791.6	27.1	299	−1869.4
Model 2 + A + B	304.6	306	−1620.4			
Model 2 + A + C	108.4	305	−1810.4			
Model 4 + B				416.3	312	−1562.7
Model 4 + C				52.5	309	−1907.4
Models in which either cocaine or crack, but not both, is taken into account in the last stage of progression						
Model 2 + A (modified)						
Cocaine only	81.5	267	−1598.2	26.6	267	−1667.0
Crack only	69.8	267	−1609.8	17.1	267	−1676.5
Model 4 (modified)						
Cocaine only	164.4	282	−1609.7	52.1	282	−1736.6
Crack only	159.8	282	−1614.3	46.3	282	−1742.4

[a]BIC = G^2–(*df*)LOG(*N*).
[b]Model 1 = alcohol or cigarettes precede marijuana, model 2 = alcohol precedes marijuana, model 3 = cigarettes precede marijuana, and model 4 = both alcohol and cigarettes precede marijuana.
[c]Hypothesis A = cigarettes required prior to cocaine/crack, hypothesis B = alcohol precedes cigarettes, and hypothesis C = cocaine precedes crack.



[a] Model 4+A+C: (1) alcohol precedes marijuana; (2) marijuana and cigarettes precede cocaine and crack; (3) cocaine precedes crack. Figure displays percentages who have reached each stage. Model accounts for 93.4% of males.

FIGURE 1—Stage model of drug involvement: male high school seniors, model 4 + A + C[a].



[a] Model 4+C: (1) alcohol and cigarettes precede marijuana; (2) marijuana precedes cocaine and crack; (3) cocaine precedes crack. Figure displays percentages who have reached each stage. Model accounts for 94.2% of females.

FIGURE 2—Stage model of drug involvement: female high school seniors, model 4 + C[a].

prior to crack. The proportions of such error types are lower among male cocaine users with no crack experience (3.8%) and the same among female cocaine users (4.9%).

Importance of Age of Onset

Age of onset into drugs is an important factor in the progression through the developmental sequence of drug use. Adolescents were classified into five mutually exclusive hierarchical groups according to their lifetime pattern of drug use: (1) never used any drugs, (2) used only alcohol and/or cigarettes, (3) used marijuana but not cocaine, (4) used cocaine but not crack, and (5) used crack. Adolescents who progressed to using cocaine, and especially crack, began smoking cigarettes, drinking alcohol, or smoking marijuana 2 years earlier, on average, than those who did not go on to use cocaine. The mean age of onset for cigarette use was 11.5 years (SD = 2.1) for cocaine users who did not use crack and 11.1 years (SD = 2.1) for crack users, compared with 13.1 years (SD = 2.7) for adolescents who only ever used alcohol or cigarettes or 12.6 (SD = 2.3) for those who went on to use marijuana. Similarly, cocaine and crack users started using marijuana almost 2 years earlier ($\bar{\chi}$ age of onset = 13.5, SD = 2.0; $\bar{\chi}$ age of onset = 13.2, SD = 2.2) than those who remained exclusively marijuana users ($\bar{\chi}$ age = 15.2, SD = 1.2). Crack users initiated the use of cocaine almost a year earlier ($\bar{\chi}$ age = 15.2, SD = 2.2) than those who used cocaine but no crack ($\bar{\chi}$ age = 16.0, SD = 1.4).

Conclusion

Although the data are cross-sectional, they provide strong evidence for a sequential pattern of drug involvement in adolescence. The earliest stage involves the use of at least one licit drug—alcohol and/or cigarettes. Subsequent stages involve marijuana and other illicit drugs such as cocaine. In the overwhelming majority of cases, crack is initiated after experience with marijuana. Of high school seniors who used crack, only 10% used it before they had first tried marijuana. The best fit overall, for both sexes, is the model that specifies an order between cocaine and crack. These data parallel findings reported for a snowball sample of minority crack-using young adults in New York City, in this sample, composed of drug arrestees, community residents, and clients in drug treatment programs: 78% had used marijuana and 63% had used cocaine in other forms prior to using crack.[10]

The results confirm a sex difference in the more important role of alcohol among males and tobacco cigarettes among females in the developmental progression of involvement into various classes of drugs. Among females, the best-fitting model is one in which cigarettes precede experimentation with marijuana, whereas among males, alcohol, even in the absence of cigarettes, consistently precedes the use of marijuana. Among males, cigarette use is an important stage prior to experimentation with illicit drugs other than marijuana and plays a somewhat stronger role later on in the sequence than it does for females. The more important role played by cigarette use early in the drug involvement sequence among females than males replicates a finding that we observed in a cohort of young adults drawn 20 years ago from earlier classes of New York State high school students.[6] (The proportions of adolescents who had used any illicit drug other than marijuana but not crack, and who had not also used alcohol or cigarettes and marijuana, were lower in 1988 [9.8%] than those observed among high school seniors surveyed in 1971 [14.6%].) The present results confirm that early onset into drugs is a crucial risk factor for progression to more serious forms of drug use.[15]

The regularity of the observed sequences at different historical periods, in different populations and in different cultures is striking.[5,16–21] However, we need greater understanding of the basic biological, psychological, social, and cultural processes underlying progression through the different pathways. □

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